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BMDO Update

Linking American Businesses to Ballistic Missile Defense Technology

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INSIDE

Battling Breast Cancer —*by Patrick Hartary*

BMDO technology joins the fight, improving disease detection, elimination, and damage control.

There's a deadly enemy stalking women. No bullets or missiles can be launched against this foe. No tanks or bombers can stop it.

The enemy is breast cancer and each day more than 100 women across the Nation die because of it. Thousands more suffer through painful surgeries—in which part or all of the breast is removed—to rid the body of this devastating disease.

There is some good news for women, though. New technologies are making great strides in detecting and treating breast cancer. Surprisingly, many of these technologies were originally developed for the Ballistic Missile Defense Organization (BMDO). While ballistic missile defense does not engage in research aimed directly at medical problems, the technologies involved are frequently similar to those needed by doctors to defeat breast cancer.

In the following paragraphs, you will read about three BMDO technologies that have already joined or will soon be joining the battle against breast cancer. The first technology will raise the mark for early breast cancer detection, while the second technology significantly improves the elimination of the disease. A third technology is designed for damage control; that is, it increases the accuracy of breast reconstruction surgery, which helps reduce the psychological stress and cosmetic concerns associated with breast removal.

Catching cancers

Early detection is one of the keys to surviving breast cancer.

Mammography, an x-ray of the breast, is the most common tool for finding breast tumors. But by the time a cancerous tumor has been found in a mammogram, it has already been growing for three to five years—sometimes longer.

OmniCorder Technologies, Inc. (Stony Brook, NY), is helping to catch tumors earlier with infrared detector technology funded by BMDO for space-based missile detection. The technology's infrared wavelength is ideal for the job because it detects subtle changes in breast temperature that indicate potentially cancerous masses.

"We use quantum well infrared photodetectors sensitive to temperature changes of less than 0.015 degree Celsius," said Mark Fauci, president and CEO of OmniCorder. "Breast cancer may escape detection from human eyes but not our infrared ones."

The photodetectors are incorporated in the company's BioScan System™, which was recently cleared by the FDA for sale as an adjunctive diagnostic screening technology for detecting breast cancer. For a scan, the patient sits in a chair while the camera device, coming to within 25 in. of the patient, records infrared light that is emitted from the breast; the

Infrared eye. *The OmniCorder BioScan system (foreground) is an infrared camera device that can view and record heat patterns generated by the human body. Analyzed by a computer (background), these patterns can help doctors to detect the early signs of breast cancer.*

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FEATURE

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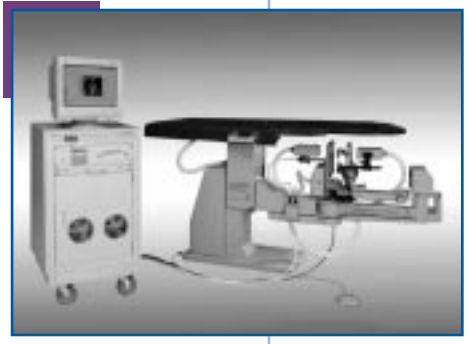
data collected are then analyzed by special software. The camera and software together create a product 100 times more sensitive and 100 times faster than earlier devices.

In a recent study, BioScan was used to differentiate between malignant and benign masses. OmniCorder believes the system will discover false positives or confirm mammogram results and thus reduce the number of biopsies, 80 percent of which are negative. The company is also testing the device to determine if it can detect breast cancers that mammograms miss.



New weapon. *Using APA technology developed for the SDI, Celsion's system safely delivers controlled deep heating to eradicate breast tumors—without harming superficial and surrounding healthy breast tissues.*

"Our vision is for the BioScan to become widely available in hospitals, clinics, and doctors' offices as a dominant means of early breast cancer detection," said Fauci. Instead of selling BioScan devices, OmniCorder plans to install them at licensed sites and charge a fee for each use. "Rather than sell a few thousand boxes, we hope to sell millions of service transactions," added Fauci. BioScan's footprint requires about the same amount of space as an ultrasound machine.

Although OmniCorder is working with several large medical device and pharmaceutical companies to commercialize its technology, the company is interested in finding a venture capital partner to help with production scale-up.

The company is also testing BioScan in therapeutic imaging and surgical applications. Researchers at Dana-Farber Cancer Institute in Boston are evaluating the system for monitoring cancer treatment and for detecting therapy-induced changes in various forms of cancer. Evaluation results were presented at the American Society of Clinical Oncology meeting in May 2001.

In addition, surgeons at the Mayo Clinic in Minneapolis are testing BioScan during brain surgery where the system is helping to identify and track malignant lesions as well as key brain functions.

Targeting tumors

Surgery isn't the most pleasant of experiences. But for many breast cancer patients, it's the only choice for treating the disease.

Celsion Corporation (Columbia, MD) has developed a new system that promises to reduce and, in some cases, eliminate the need for breast cancer surgery. The system capitalizes on missile surveillance technology funded by the Strategic Defense Initiative Organization, now BMDO.

Adaptive phased array (APA) technology was originally intended to target microwave energy on an enemy missile while simultaneously nullifying enemy jammers. But Celsion has applied this technology to breast cancer treatment, focusing microwave heat on tumors while nullifying the microwaves that would otherwise heat a patient's skin or healthy tissue.

"The first generation of microwave machines were likely to burn patients with deep-seated tumors without eradicating their cancers," said John Mon, Celsion's vice president of new business development. "Using APA technology, our system can aim microwaves so they reach peak intensity in a tumor, rather than in surrounding healthy tissue. It's a big advance in safety."

Celsion's system may be FDA approved for sale as a breast cancer treatment tool as early as 2002. During treatment, the patient lies prone on a table similar to that used in breast biopsies. The patient receives a single 20- to 40-minute microwave treatment during which the breast tumor is heated to about 115ºF—hot enough to heat and kill cells containing high amounts of water. Breast cancer cells are about 80 percent water while healthy cells in breast tissue contain only about 20- to 60-percent water.

"In the first tests of the system, we learned that small and large tumors cannot be treated the same way," said Mon. "Therefore, we have developed two different protocols for using our technology to optimize the treatment for breast cancer patients."

When a patient has a small tumor and is scheduled for a lumpectomy, Celsion's system can be used alone to completely destroy the cancerous tissue, making the surgery safer and reducing the size of the lumpectomy procedure. This would allow surgeons to remove a small, dead tumor instead of a live tumor as is done in current lumpectomies.

For patients with medium to large tumors and who are scheduled for a mastectomy, Celsion's system can be used along with chemotherapy to shrink the tumors sufficiently, allowing breast-conserving lumpectomies to be performed

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instead of complete mastectomies. Alone, chemotherapy is only 20- to 30-percent effective in shrinking this size of tumor. Combined with Celsion's system, tumor shrinking becomes significantly more effective.

Like OmniCorder, Celsion intends to license its breast cancer treatment systems and then bill the licensee per service. It is also looking for new investors to help the company complete the FDA trials and ramp up for commercial production.

Other medical applications for Celsion's focused-heat technology abound. The company is looking into temperature-sensitive, drug-laden liposomes, which will work with its focused heat systems to target prostate, liver, ovarian, and other cancers. It is also developing heat-activated gene therapy treatments to keep tumors from repairing themselves after radiation and chemotherapy.

Reconstructing breasts

Reconstructing a breast after surgery can be a tricky job for surgeons. The goal, of course, is to make the new breast as natural-looking as possible, and to match the size and shape of the other breast. However, flat, two-dimensional photographs don't convey the volume or the true shape of the breast.

Genex Technology, Inc. (Kensington, MD), has developed a 3-D camera that allows breast surgeons to calculate that volume. "With this camera, we can create an accurate picture of the breast and generate objective three-dimensional data," said Greg Galdino, a resident surgeon at Johns Hopkins University's Division of Plastic and Reconstructive Surgery. "These data are quite useful to the surgeon in determining the volume of tissue or implant needed for the reconstructed breast."

The Rainbow 3-D Camera™ was originally developed for BMDO to track enemy missiles in space. By emitting a cascade of colored lights and measuring their reflection in wavelengths from various objects, the device calculates the distance to each object. It captures 300,000 such measurement points in each frame at a speed of 30 frames per second, equivalent to the speed of video. With real-time 3-D imaging data, BMDO can view missile trajectories on 3-D displays, or surgeons can see and measure the breast more accurately.

Twenty-five patients undergoing breast reconstruction or augmentation surgery at the hospital have already been scanned by the camera. Before each surgery, the device was used to determine the amount of volume needed to make the new breast symmetrical with the volume of the implant used. The result of the study showed that the camera provided a reliable guide for determining breast symmetry, volume, and shape prior to mastectomy, and for determining distribution of implant volume after augmentation.

Galdino said the goal is to develop a camera system that enables computer models to project what the finished breast will look like. Ideally, this system would be used when consulting with a patient pre-operatively. "After the camera captures the image, we'll be able to alter that image to the patient's liking or satisfaction," added Galdino. "That's always been the big dilemma in communication between the surgeon and patient."

In addition to breast reconstruction, the camera has other medical and non-medical applications. According to Genex Technology, the device is now part of a computerized tool that helps dentists accurately design prostheses, including crowns, bridges, and dentures. It also has been incorporated in a rapid prototyping system that builds complex shapes from 3-D models.

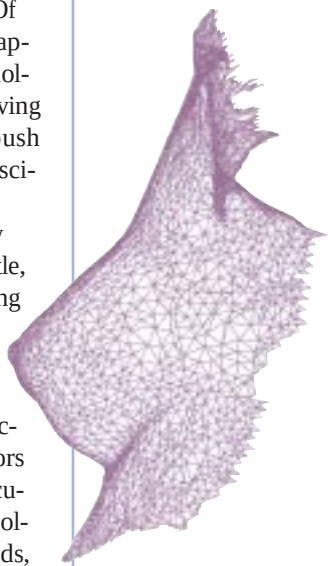
Imaging tool. *Genex's 3-D camera, originally designed for tracking enemy missiles, is now being used by surgeons and dentists for imaging applications.*

Winning battles

Over the years, great strides have been made in diagnosing and treating breast cancer. Of course, these gains didn't happen by accident. New technology helped pave the way, giving doctors advanced tools to push forward the boundaries of science and medicine.

Now, BMDO technology is at the forefront of the battle, beefing up the cancer-fighting arsenal. It's detecting cancers far earlier than mammograms. It's getting rid of cancerous tumors more effectively. And it's helping doctors reconstruct breasts more accurately. As more BMDO technology ends up in doctors' hands, one can only hope that more battles will be fought and won, and that the war on breast cancer will be that much closer to ending, forever.

☑ Contact Mark Fauci of OmniCorder Technologies at (631) 444-6499, John Mon of Celsion Corporation at (410) 290-5390, and Jason Geng of Genex Technologies at (301) 962-6565. Or, on the reader request card, check 3401 for OmniCorder, 3402 for Celsion, and 3403 for Genex.



Reliable guide. *For breast reconstruction, surgeons rely on Genex's 3-D camera to supply over 300,000 data points and landmarks per image. A 3-D image acquired by the camera is pictured above; its resolution has been reduced for visualization purposes.*

STRUCTURING STOCK OWNERSHIP

This is the first in a series of frequently asked questions (FAQs) from the National Technology Transfer Center's Business Focus Workshops (BFWs), one-day business development sessions that the NTTC conducts for BMDO-funded researchers. The goal of the BFW is to help these researchers develop a market focus, so that the technology will find its way to practical use more quickly. In BFWs, BMDO-funded researchers discuss commercialization strategy one-on-one with an experienced business consultant, develop the foundations of a business plan, and lay out milestones for commercial success. This consulting session is followed by a brief presentation to a larger group of consultants who critique the plan.

These FAQs are designed to answer some of the common questions that researchers have when structuring their businesses for commercial success. In this FAQ, our BFW consulting staff addresses the question of stock ownership in a start-up company.

Avoid management headaches by structuring stock ownership before the first round of financing.

What is the best way to structure stock ownership in my start-up business?

Too often, a start-up owner does not treat stock ownership as a capital asset to be utilized with discretion and balance. He may hoard stock ownership, thinking that if too much of the company is given up, control (financial, parental, or both) of the technology will be lost. In doing so, he is giving up one of the most important tools for growing his company. For example, most start-ups cannot offer the large salaries needed to attract top-notch employees, and don't have the money to hire outside consultants, directors, or advisory members. To compensate for the lack of cash, the smart start-up owner will offer future wealth (in the form of stock ownership) to acquire quality advice and performance.

While it's probably more common to hoard stock, some start-ups give too much stock away in an effort to aggressively jump-start the business. This can dilute the value of the company, making it unattractive to outside investors. It can also lead to management headaches.

TABLE 1:
STOCK DISTRIBUTION AT FIRST ROUND OF FINANCING

CEO	4-10%
VP Marketing	2-6%
VP Finance	1-2%
External Director	0.5-1%
Engineering Manager	0.25-1%
Advisory Board and Senior Engineer	0.1-0.25%
Engineer	0.05-0.1%

So, what is the best way to distribute private stock ownership? While there is no set formula for this distribution, rough guidelines exist that can be adjusted to each company's special circumstances (the nature of the business, the number of participants, extent of family involvement, etc.). Table 1 provides typical ownership guidelines for the first round of financing, which is adapted from a short course given by Dr. Milton Chang at the 1997 Conference on Optical Fiber Communications in Dallas, Texas. The existing investor pool typically holds all additional shares, or they can be held in a stock pool for additional new investors. In addition, some professional investors suggest management and employees retain 25 to 30 percent of all stock after the first round and 4 percent after an IPO.[1]

Early on in the enterprise, the value of this stock is established in the form of intellectual property, product ideas, and the aggregate of professional talent. The dollar value of a start-up company is difficult to assess, hence the stock distribution plan is established on a percent of ownership basis. Later on, the value of the enterprise is established by the fair market value of the stock if the stock is publicly traded.

—T. Lynch and T. Hartwick

Want to know more? Business Focus Workshops are open to all BMDO-funded researchers on a space-available basis. If you are interested in attending a future workshop, call the BMDO Update *request line at (703) 518-8800, ext. 500, or e-mail us at update@nttc.edu.*

[1]Michael L. Baird, "Engineering Your Start-Up," Professional Publications Inc., 1999.

HEADS UP

NEW TECHNOLOGY REPORT FOCUSES ON FIBER-OPTIC TELECOMMUNICATIONS

In 1998, the BMDO Technology Applications program published *BMDO Fiber-Optic Technologies for Telecommunications*, a 27-page report highlighting BMDO-funded research in optical amplifiers and WDM devices. Since then, thousands have obtained this report either by mailing in the *BMDO Update* readership request card or by accessing the publication online through BMDOLINK's technology transfer section. Buoyed by this success, the program has developed a follow-on report that, once again, centers on state-of-the-art technology for fiber-optic telecommunications.

This time, the report focuses on BMDO-funded optical-core photonic switches and optical circuitry—two technology areas that are key to building out the telecommunications infrastructure. Optical-core switches will dramatically reduce "bottlenecking" on fiber-optic networks by eliminating electro-optic signal conversions. Meanwhile, more advanced optical circuitry will help networks fully realize the capacity gains afforded by optical-core switches and other advanced fiber-optic components.

More than a dozen small yet rapidly growing companies, including Radiant Photonics, SpectraSwitch, Chorum Technologies, and New Span Opto-Technology, are highlighted in the report. A technical description of each company's technology and how it is being or can be applied in fiber-optic telecommunications is provided. Readers will also appreciate the company point-of-contact information, including e-mail and Web site addresses, included in the report.

—P. Hartary

☑ To receive a free copy, check 3404 for the previous report on optical amplifiers and WDM devices and/or check 3405 for the new report on optical-core photonic switches and optical circuitry on the reader request card.

A new report focusing on optical switches and optical circuitry funded by BMDO is now available.

COMMERCIALIZATION: IT'S GOOD FOR BMDO

Commercialization of BMDO technology helps the U.S. economy by injecting new products into the marketplace. But it also helps BMDO by sustaining the agency's seed-stage research until it is ready for military acquisition. Oftentimes, commercialization can reduce the cost and/or improve the performance of the technology as well. To view examples of BMDO technology spin-ins, visit http://www.acq.osd.mil/bmdo/bmdolink/html/spinins.htm.

YEAR'S BEST SBIR TECHNOLOGY FUNDED BY BMDO

Two BMDO-funded companies received Technology of the Year awards at the Small Business Innovation Research (SBIR) and Small Business Technology Expo last November. These awards recognize important new commercial products and services developed through the Federal government's SBIR program, the largest source of early-stage R&D financing in the United States.

In the sensors and instrumentation category, Applied Optoelectronics, Inc. (Sugar Land, TX), won its award for a mid-infrared semiconductor laser (highlighted in the Summer 2000 *BMDO Update*). A product of BMDO SBIR funding, the interband cascade laser offers spectroscopic applications ranging from medical analysis of chemical compounds (such as instant assessment of cholesterol levels) to real-time detection of drugs and explosives.

In the industrial and manufacturing category, QRDC, Inc. (Chaska, MN), received its award for a vibration-reducing technology (highlighted in the Spring 2001 *BMDO Update*). Also developed with BMDO funding, the Energy-Based Smart Skin Structure™ can be used to eliminate cabin noise in passenger aircraft. Other applications include smart wallpapers, computer enclosures, and clean rooms where even the smallest noise disturbances cannot be tolerated.

Picolight and EMCORE are two BMDO-funded companies that won Technology of the Year awards at last year's event.

—P. Hartary

FOR NANOMATERIALS, BULK IS BETTER

While the infant nanomaterials industry trumpets fanciful advances from hair-thin fibers strong enough to hold up suspension bridges to lighter and more powerful energy storage devices, practical concerns such as cost, quality, handling, and availability in bulk have so far relegated these exotic materials to the lab. However, one nanomaterials company, AP Materials, Inc. (St. Louis, MO), has developed a practical process in a BMDO SBIR contract for producing non-oxide (e.g. pure metal or non-oxide ceramic) nanopowders to address these limitations head-on. The result may be a new generation of stronger, cheaper advanced materials.

AP Materials' sodium/halide flame and encapsulation (SFE) process produces tiny nanoscale particles and then encapsulates them during the aerosol growth stage of the process. Encapsulating the tiny particles within the process protects them from oxidation or hydrolysis when they are later exposed to air, thereby maintaining the purity. Additionally, the SFE process can be used to control the size, shape, and connectivity of the nanoparticles. When compared with other processes capable of producing nanoparticles, the SFE process requires less energy and avoids the costly steps required to shield the powders from contamination due to atmospheric exposure during handling, storage, and transportation. Furthermore, the processing costs using AP Materials' approach are competitive with existing commercial micron-sized powder production techniques.

For missile defense applications, the BMDO SBIR program funded AP Materials to refine the process to make lightweight metal-matrix composites. Such composites can be used for missile defense components requiring high strength and light weight. In the commercial sector, the material can be used for high wear applications (e.g. brake parts) and sporting goods. Addressing larger markets, the process can be tailored

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NANOSONIC DEMONSTRATES SELF-ASSEMBLY PROCESS

The ability of molecular self-assembly to achieve fine geometric control of nanoparticles could pave the way to more efficient thin-film manufacturing. While self-assembly research is still in the early phases at most labs, NanoSonic, Inc. (Blacksburg, VA), is ahead of the pack with its own electrostatic self-assembly (ESA) process—one that produces thin films with superior electrical, piezoelectric, and optical material properties. ESA involves repeatedly dipping the substrate into alternate aqueous solutions containing anionic and cationic materials. The process can be performed at room temperature on a variety of substrate materials and is environmentally benign.

In the lab. *NanoSonic researchers use extensive material characterizations to confirm the structure and properties of nanomaterials and devices.*

Thus far, NanoSonic has synthesized a wide range of inorganic oxide nanoclusters, noble metal nanoclusters, and other molecules and has demonstrated their synthesis into thin-film materials by ESA processing. These inorganic clusters lead to ultrahard, abrasion-resistant coatings, and noble metal clusters like platinum, which could be used to boost the performance of energy-storage technologies such as batteries. NanoSonic is creating a "library" of other self-assembled materials with commercial potential. For example, ESA materials with superior electrical properties could be used as conformal electrodes on ultrasmall electronic devices and as electrically conducting surface coatings on ceramic, polymer, and other substrates. The electrical conductivity of these films is superior to that of conducting polymers and conventional opto-electronic electrode materials such as indium tin oxide.

NanoSonic licensed nine ESA-related patents from Virginia Tech, which developed the technique. With subsequent BMDO STTR and SBIR contracts, NanoSonic demonstrated the feasibility of using ESA to produce higher performance electro-optic materials as well as materials with superior photonic properties. Within 2 to 5 years, NanoSonic will start selling selected thin films and eventually sell a full line of films and processing machines, while also licensing out its processes to other companies. The company welcomes inquiries from investors or companies interested in commercial development of the ESA process.

—J. Jackson

☑ Contact Richard Claus of NanoSonic at (540) 953-1785 or check 3406 on the reader request card.

ELECTRONICS

FILM ADHESIVE OFFERS HIGH YIELDS AND THERMAL CONDUCTIVITY

The die attach process—during which an integrated circuit is mounted to lead frames or substrates—can cause irreparable damage to semiconductor dice. Those dice now have a better chance of surviving the process, thanks to a new thermally conductive adhesive film developed by *btech*corp (Longmont, CO). The advanced thermal transfer adhesive, also known as ATTA®, combines the thermal conductivity of solder with the process-friendliness of epoxy.

While solder is an attractive joining material because of its high thermal conductivity, its high melting temperature causes problems in die attach applications. Exposing the die and substrate to such high temperatures causes coefficient of thermal expansion (CTE) stress between the two materials as they cool. Damage from CTE stress can reduce production yield by as much as 10 percent. ATTA's lower curing temperature could avoid these losses and increase yield, resulting in significant savings for manufacturers and end-users such as BMDO.

Lower process temperatures are possible with another die attach adhesive—silver-filled epoxy—but its low thermal conductivity is a significant drawback. Heat sinks attached with epoxy cannot effectively do their job if the heat they are designed to remove first gets trapped in that epoxy. Densely-packed z-axis carbon fibers contribute to ATTA's high thermal conductivity and allow heat to be transferred efficiently while bonding together materials such as silicon, chemical vapor-deposited diamond, plastics, or ceramics.

In addition, *btech*corp is testing a modified version of its film for use in flat-panel displays. The company found that it could give ATTA a high electrical conductivity by applying a metallic coating to the carbon fibers, making the film an ideal display interconnect material (with a pitch of less than 10 microns and a cure of 25 pounds per square inch at 120ºC). Today's display devices rely on less-dense and less-conductive alternatives. The ATTA film is ready for bonding applications and *btech*corp welcomes inquiries from potential customers.

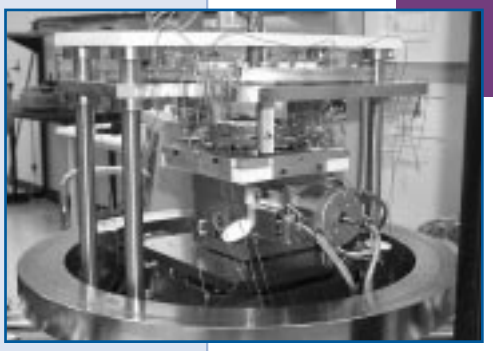
—J. Huergo

☑ Contact Jay Browne of *btech*corp at (303) 652-6418 or check 3408 on the reader request card.

Densely packed carbon fibers oriented in the z-axis are key to btechcorp's *high thermally conductive adhesive.*

ARRAYS, SOFTWARE BOOST ELECTRON BEAM LITHOGRAPHY THROUGHPUT

NOVA Scientific, Inc. (Sturbridge, MA), is close to bringing the throughput of today's optical lithography systems to a next-generation electron beam lithography tool. This combination may help bring electron beam lithography—which can write features considerably smaller than today's optical systems—out of the laboratory and into commercial semiconductor fabs. To develop the electron beam technology, NOVA teamed with The Lockwood Group to form a partnership called Emission Systems LLC. The collaboration leveraged funding from the BMDO SBIR program as well as DARPA; both agencies could benefit from improvements in the yield of sub 100-nm lithography.



Working prototype. *NOVA Scientific has developed an e-beam lithography "Source Cartridge" containing an array that produces multiple electron beams down to 60 nm. The effectiveness of this unit has already been demonstrated by drawing lines and creating uniform dots.*

While standard lithography tools use single electron beams, Emission Systems has assembled many thousands of parallel beams into an array. Working with a computer control program called SoftMask™, individual beams in the array are switched on and off, creating the desired pattern on a resist-coated wafer. This will eliminate the need for a traditional mask and allow for large-scale patterning at higher throughput rates. The Emission Systems lithographic tool combines a field emitter cluster with a microchannel amplifier to increase the stability of the field emitter's electron beam. This all-silicon array structure allows the field emitter to operate at low currents, offering increased reliability and stability, the basis for swift chip production. Emission Systems is looking for venture capital to build a prototype lithographic tool.

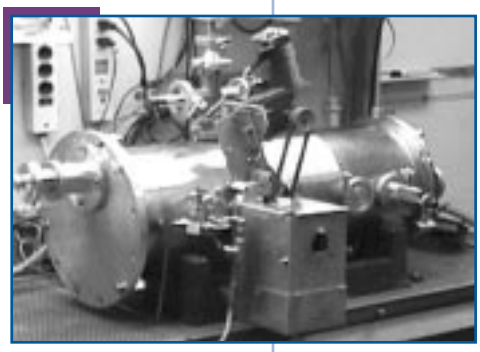
—A. Haar

☑ Contact Harry Lockwood of Emission Systems at (617) 965-3565 or check 3409 on the reader request card.

ELECTRONICS

SPUTTER DEPOSITION: IT'S NOT JUST FOR METALS ANYMORE

Magnetron sputtering is a fast and economical way to deposit metal and metal-oxide films. But making the process work for non-metals and compounds has not proven economic—until now. Thanks to BMDO-funded SBIR materials research, Solar Associates (Merritt Island, FL) has developed a new magnetron sputtering system for non-metals that retains the speed and economy of conventional magnetron sputtering, while allowing real-time control of the stoichiometry and particle energy of the depositing films.



New opportunities. *Solar Associate's surrogate magnetron sputtering system makes possible economical sputter deposition of non-metals and compounds with real-time control of material ratios.*

Conventional magnetron sputtering of non-metals (especially oxygen) produces negative ions with energies of about 500 electron volts (eV), which damage the resulting compound thin films and often the substrates as well. In the new Solar Associates system, microwaves decrease the sputter plasma voltage to between 30 eV and 100 eV—levels that will not cause negative ion bombardment damage to III-V semiconductors or other fragile materials. Deposition rates remain as high or higher than conventional magnetron sputtering.

The Solar Associates device also makes it possible to create compound films without expensive and fragile compound targets. Material from up to four individual targets can be simultaneously sputtered—in ratios controlled by a simple dial—onto a rotating surrogate magnetron disc or cylinder. From there, the combined elements are sputtered onto the final substrate to form compound films such as gallium arsenide, gallium indium phosphide, or transparent conducting oxides. Because the Solar Associates system is low-temperature, unconventional substrates can be used, including plastic. Applications for these thin films include solar cells, Hall Effect sensors, flat-panel displays, and batteries.

Solar Associates is building a pilot sputtering system for Bell Technologies and welcomes inquiries from potential customers.

—J. Huergo

☑ Contact Curt Lampkin of Solar Associates at (407) 678-6900 or check 3410 on the reader request card.

"The desire to know is natural to good men."

—Leonardo da Vinci

PURE GAS FLOWS MAY BE A BOON TO CHEMISTS, CHIPMAKERS

Extremely pure, hot flows of volatile gas are necessary for cleaning and stripping during semiconductor manufacture. Unfortunately, these gases tend to corrode the very equipment that contains and heats them, adding chip-damaging contaminants to the flows. Physical Sciences, Inc. (PSI; Andover, MA), has found a way to avoid contamination with its electrode-less, microwave-driven MID-Jet™, a plasma torch that can create pure flows of even the most volatile gases.

In competing torches, electrodes are often corroded and contaminate the gas flow. Such contamination could damage delicate semiconductor devices or jeopardize chemical reactions. By doing away with electrodes in its MID-Jet plasma torch, PSI has removed a source of contamination and made a more flexible device that can handle the most corrosive gases, including fluorine. The MID-Jet also lacks a dielectric tube, instead relying on a vortex flow to contain the gas or gases during heating by microwaves. Glass or sapphire dielectric tubes can be damaged at high temperatures, limiting a torch's thermal range. Without a dielectric, the MID-Jet can heat gases to temperatures over 6,000ºC.

The MID-Jet is ready for customers and can be adapted for hot flows of gas or steam under vacuum or atmospheric pressures with microwave drive powers ranging from 1 kW to 30 kW, depending on the model. The plasma torch was an outgrowth of BMDO-funded SBIR research into development of a plasma sprayer for corrosion-resistant coatings.

—J. Huergo

☑ Contact Michael Read of PSI at (703) 941-0495 or check 3411 on the reader request card.

OPTICAL COMMUNICATIONS

CORNING GETS A HANDLE ON OPTICAL POLARIZATION

A new line of compact polarization controllers with roots in BMDO-funded materials research will help pave the way for greater telecom bandwidth. Marketed under the trade name Acrobat™ Series of Polarization Controllers, these devices, developed by Corning Applied Technologies (Woburn, MA), will help alleviate the problem of polarization-mode dispersion (PMD)—a growing problem as telecommunications companies upgrade to 10- and 40-gigabit fiber-optic equipment. PMD occurs as different polarization modes of a signal travel down a fiber at different speeds, smearing the signal. This problem grows more pronounced at higher bandwidths because the signals are more closely spaced. When incorporated into a polarization-mode dispersion compensator (PMDC), the Acrobat polarization controller corrects for dispersion by converting a signal consisting of several polarization modes to a single-mode signal.

Light speed ahead. *A polarization controller developed by Corning Applied Technologies may help telecommunications carriers get greater throughputs from their fiber-optic lines.*

The Acrobat line is based on OptoCeramic™ technology, a class of proprietary materials having high electro-optic coefficients, which were developed in part by BMDO SBIR research for smaller, faster fiber-optic components. Corning Applied Technologies, then an independent company called NZ Applied Technologies, developed materials that possessed crystalline structures with indeces of refraction that could be changed via electric signals, thereby making them able to perform many of the functions of larger mechanically driven optical components.

In 1999, Corning Applied Technologies introduced the Eclipse™ Series of Variable Optical Attenuators, also based on OptoCeramic technology. This attenuator, only one-tenth the size of other compact attenuators, has since enjoyed widespread industry use, particularly in Europe and Japan. The same solid-state design is used for the Acrobat polarization controller, which also enjoy radically smaller size and can be easily used in arrays. In addition to use in PMDCs, these devices could also be used in polarization generators, polarization scramblers, and polarization multiplexers, and as a value-add

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OPTICAL INTERCONNECTS SPEED MULTI-CHIP COMMUNICATIONS

As chip-driven circuitry grows ever more complex, component manufacturers clamor for a way to speed throughput, cut energy use, and simplify the tangle of wire and bus connections in multi-chip modules. Researchers at George Mason University (GMU; Fairfax, VA) are developing an optical backplane that could do away with most of the electrical interconnects and raise throughput to unprecedented terabit-levels. Aspects of this technology have been partially supported by the Air Force Office of Scientific Research, DARPA, and the BMDO Innovative Science and Technology program.

Called Free-space Accelerator for Switching Terabit Networks (FAST-Net), this backplane employs "smart pixels" that use arrays of vertical cavity surface-emitting lasers (VCSELs) and detectors to connect multiple chips. In GMU's "two-bounce architecture," arbitrary point-to-point interconnection can be constructed with a maximum of two passes from VCSELs to detectors. This is achieved through the combination of global optical interconnections with local electronic "on-chip" routing. As a result, the architecture possesses an optimal combination of high connectivity and fast transmission speeds that offers a competitive advantage over other designs now being developed.

Once realized, optical interconnection architectures, such as FAST-Net, will have immense value for the manufacturers of computers and other microchip-run devices. Thus far, the GMU-led team has demonstrated a backplane consisting of a 4 x 4 array of smart pixels, each containing an 8 x 8 array of VCSEL/detector pairs, and plans to replace the arrays with 32 x 32 elements by 2002. To pursue commercial opportunities, a separate company called Applied Photonics was created to investigate uses of FAST-Net for general purpose switching fabrics for multiprocessor communications, and for high performance forward-error-correction communications decoding. GMU welcomes inquires from companies interested in strategic partnerships for these and other uses.

—J. Jackson

☑ Contact Dr. Michael Haney of George Mason at (703) 993-1571 or check 3413 on the reader request card.

GMU researchers have spun off a new company called Applied Photonics to commercialize their BMDO-funded VCSEL technology.

MANUFACTURING

WHEN CLEAN IS TOO CLEAN

Keeping it clean. *A well-developed contamination control plan saved money on the MSX project and kept contaminants from interfering with mission goals.*

In satellites, contamination from grease, dust, or other particles can interfere with sensors or cause electrical shorts. A seemingly obvious resolution to this problem might be to build all satellites in ultraclean facilities, or to avoid any contamination-causing materials. But not only would the expense of such precautions be out of reach for many missions, that level of cleanliness could be unnecessary (a two-month mission, for example, would not be hampered by contamination build-up that takes years to reach damaging levels). To help satellite manufacturers better determine contamination control needs, researchers at the Johns Hopkins University Applied Physics Laboratory (APL; Laurel, MD) devoted room on BMDO's Midcourse Space Experiment (MSX) to evaluate their own contamination control plan. The plan saved the MSX mission an estimated $1 to $2 million dollars and has led to improved contamination monitoring devices as well as a database of materials information.

To monitor the effectiveness of the control plan, the MSX was outfitted with sensitive instruments such as a quartz crystal microbalance (QCM) from QCM Research (Laguna Beach, CA), which measures films from condensation or outgassing. As a result of research to include the QCM in the MSX mission, the cost of the device dropped nearly 50 percent, its diameter decreased from 2 in. to 0.5 in., and its overall sensitivity increased. The new QCM will be used in the Space Shuttle and Standard Missile programs. Other devices on board the MSX—a total pressure sensor from Sentran Company; a neutral mass spectrometer from the Space Physics Research Laboratory at the University of Michigan; an ion mass spectrometer from Ideas (now SAIC); and krypton and xenon flashlamps from Visidyne, Inc.—were improved or validated as a result of their participation in the MSX mission.

Satellite manufacturers have also benefitted from a database, commissioned by NASA, that relies heavily on MSX mission data. The Satellite Contamination and Materials Outgassing Knowledgebase (http://see.msfc.nasa.gov/see/nec/db_contam.html), contains data to help satellite makers in the design, manufacture, and operation of more reliable, cost-effective spacecraft for the government and commercial sectors.

—J. Huergo

☑ Contact Manny Uy of APL at (240) 228-5334 or check 3414 on the reader request card.

TUNABLE LASER COVERS DEEP-UV TO MID-IR WAVELENGTHS

The broad tunability of Light Age's laser could prove useful for commercial applications in holography, spectroscopy, electronics, and telecommunications.

A reliable, versatile laser developed by Light Age, Inc. (Somerset, NJ), could help expand existing markets—and perhaps open new ones—for high-power (in the 10 J/pulse range) lasers now used in surgery, manufacturing, and imaging. This alexandrite-pumped, lithium fluoride (LiF) laser is tunable over the entire visible spectrum and beyond. To achieve this spectral reach, Light Age teamed with Dr. Sergey Mirov at the University of Alabama-Birmingham in its BMDO SBIR contract to develop a way to mix the LiF and alexandrite output using nonlinear optics. This mixing technique, combined with the two lasers' inherent tunability, allows spectral coverage from 190 nanometers past 12 microns.

While applications development is still in its infancy, this laser could have considerable commercial potential. For instance, its ability to cover the full visible spectrum could expand the use of three-color holography, because a single laser source could replace the three lasers currently used. The broad tunability of the laser may also prove useful for spectroscopic applications, or it may help speed the development of new fixed line applications that cannot be addressed with existing laser technology. Increased reliability and the elimination of toxic gases and dyes used in alternative laser sources may also prove to be big benefits of this all solid-state laser. Light Age anticipates delivering its first commercial products by late summer, with possible target markets in electronics and telecommunications component manufacturing in addition to those mentioned above.

—T. Lynch and A. Haar

☑ Contact Brian Pryor of Light Age at (732) 563-0600 or check 3415 on the reader request card.

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ADVANCED MATERIALS

For Nanomaterials… from page 6

to make other powder materials of interest to the electronics market (e.g. thermal management substrates, capacitors, etc.). AP Materials is scaling up the process for bulk production and welcomes calls from potential investors.

—L. Aitcheson

☑ Contact Dr. Lee Rosen of AP Materials at (314) 615-6302 or check 3407 on the reader request card.

OPTICAL COMMUNICATIONS

Corning Gets… from page 9

to other optical components such as beam splitters. Corning Applied Technologies welcomes inquiries from manufacturers interested in incorporating the Acrobat polarization controllers into PMDCs and other applications.

—J. Jackson

☑ Contact Peter Norris of Corning Applied Technologies at (781) 935-2030, ext. 4927, or check 3412 on the reader request card.

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